TRIPLE PLAY SERVICES IN XG-PON NETWORKS

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Abstract: This paper focuses on Triple Play services in XG-PON networks and their implementation and analysis in NS-3. Nowadays, Triple Play services dominate copper/optical networks. The network simulator allowed simulation of Passive Optical Networks (PON), especially XG-PON. Each service in the XG-PON simulation is represented OnOff application with different parameters. This article describes implementation and analysis of these services in basic topology of the XG-PON network.

Keywords: XG-PON, Triple Play, NS-3

1 INTRODUCTION

Triple Play is a combination of three services (voice, video, and data) [1]. The first service; and the one with the highest priority is voice. The transferring of voice occurs using one of the VoIP (Voice Over Internet Protocol) protocols. In most cases, the protocol used is SIP (Session Initiation Protocol). When a subscriber wants to call another subscriber, it's necessary to initialize a connection. The main advantage of using this protocol for the transfer of voice over optical/copper networks is that it's a lower cost to the subscriber than paying for public telephone service.

The second service of the Triple Play package is video transfer. In general, we should mention UDP (User Data Protocol) and TCP (Transmission Control Protocol) transport protocols. When we talk about video streaming, the better parameters use UDP transport protocol, because it uses unconfirmed transferring. Neither packet confirms after transferring. For this reason, UDP has better transferring parameters. In general, for video streaming – live streaming – where the multicast technique is used, UDP protocol is the best protocol to use. On the other hand, video streaming should be represented with VoD (Video on Demand) service. For VoD, a subscriber can potentially be the only person viewing the programme at the time they are watching it. This option strictly uses TCP transport protocol with confirmation of delivery.

The third and last service of the Triple Play package is data transmission. Data has the lowest transfer priority over the network. In general, it's not important when data should be delivered to the subscriber. For example, the downloading process could take a long time when compared to voice transfer (after a 10 second delay the speech is at a different location than before the delay).

Passive Optical Networks are widely used around the world. The first standard of this type of network was APON (ATM Passive Optical Networks) in 1998. APON used ATM (Asynchronous Transfer Mode) for transport data from/for user into/to Internet. The second version of APON was known as BPON (Broadband PON). Both of them are very similar. The main difference is the use of WDM (Wavelength Division Multiplexing) in BPON networks. On the other hand, BPON networks were compatible with both ATM and Ethernet protocols. When the BPON was approved in 1999, study group 15 from the ITU (International Telecommunication Union) consortium started work on the first standard with one gigabit transfer speed. The final version of GPON (Gigabit PON) was approved in 2003 [2]. The bandwidth requirements are increasing every year from 50 to 70 % [3]. Because of continually increasing available bandwidth, the study group approved the newest standard XG-PON in 2010. The next demand for increased bandwidth came from the expansion of Video on Demand services, and the very popular full HD video transmission. Downstream transmission speed was increased four times to 9.95328 Gbps and for upstream to 2.48832 Gbps [4]. For the NG-PON network, two attenuation plans were proposed: Nominal1 = 14–29 dB and Nominal2 = 16–31 dB [4]. The physical reach of the XG-PON network is the same as that of GPON and it is 20 km, which can be increased up to 60 km [4]. The range of wavelengths assigned by ITU-T to NG-PON networks is 1575–1580 nm for downstream and 1290–1330 nm for upstream. The general scheme of XG-PON networks is shown in Fig. 1.

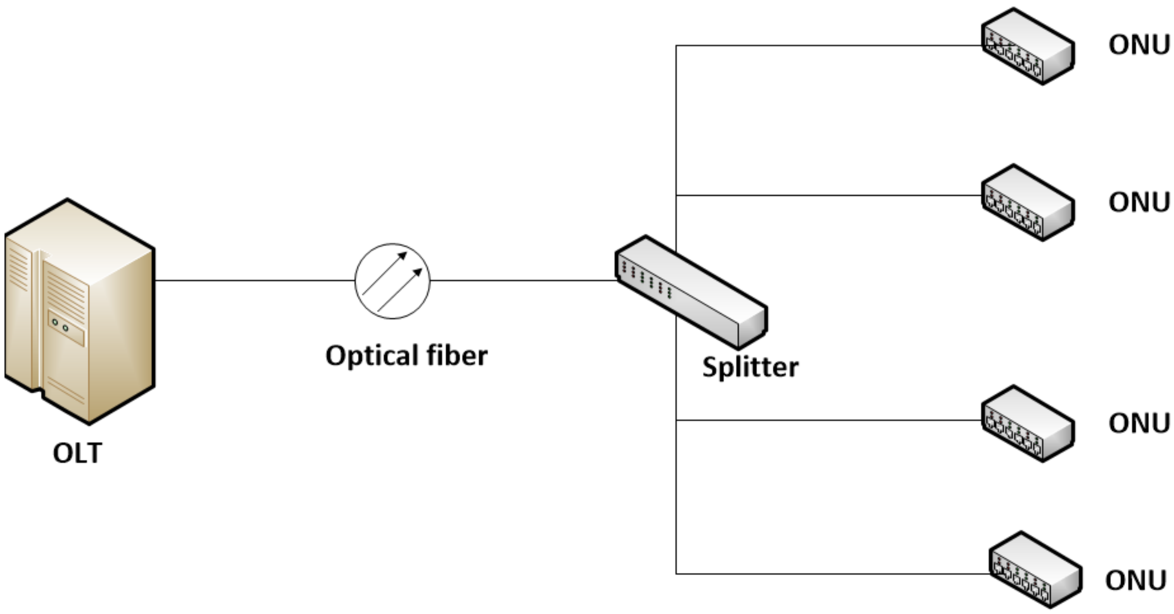

Figure 1: General scheme for passive optical networks with XG-PON standard

In Fig. 1, presents a diagram of the general scheme, which contains three parts: OLT (Optical Line Termination), a splitter, and several ONU (Optical Network Unit). Optical line termination is located at the central office of the ISP (Internet Services Provider). The central office represents the main source of TV (Television) programme streams, local streams, and so on. The ONU represents the end of the optical network. Optical Network Units are used to convert signals from optical to electric. The last part is the splitter. Splitters are used to split up the incoming signal across all ports (for XG-PON into 64 ports).

2 NS-3

The simulation program was developed by the NS-3 Consortium. It is a discrete events network simulator. This application offers many opportunities in network design. On the other hand, the primary scopes of NS-3 are simulations of LTE (Long Term Evolution), WiFi (Wireless Fidelity), and many other technologies and networks. In general, for simulation of passive optical networks it is necessary to implement the XG-PON package. Package and documentations of XG-PON should be downloaded from [5].

3 SIMULATION SET UP

For our research, an NS-3 simulator was used. As was mentioned in the introduction section, the Triple Play package is widely offered around the world. The basic scheme in Fig. 2 was implemented in NS-3. The final scheme of a simulated network can be seen in Fig. 2.

Figure 2: The topology for NS-3 simulation.

Global setup, along with complete topology and application are beyond the scope of this article, but as an example, the following code represents PPV (Pay Per View) service.

```
ApplicationContainer ppvApp, ppvApps, sinkApp;
uint16_t clientPort=6000;

UdpEchoClientHelper echoClientPPV (p2pSInterfaces[0].
GetAddress(0), 50000);

echoClientPPV.SetAttribute ("MaxPackets", UintegerValue (1));
echoClientPPV.SetAttribute ("Interval", TimeValue (Seconds (1.0)));
echoClientPPV.SetAttribute ("PacketSize", UintegerValue (1024));

ApplicationContainer ppvApp = echoClientPPV.Install
(clientNodes.Get (0));
ppvApp.Start (Seconds (3.5));
ppvApp.Stop (Seconds (4.0));
```

The code shown above defines the PPV application. As we can see, the PPV application is divided into three parts: two parts for PPV applications on the server side one client side application. The destination port in the client's computer is port 6000. Application ppvApp used helper for an assigned end and parameters were set up. The echoClientPPV.Install command defines the client node and gets his address. The last ones, Start and Stop, are time definition in seconds during the simulation.

4 SIMULATION RESULTS

If we want to see packets in raw format, we need to add the following line into the source code in Eclipse: .

```
xgponHelper.EnablePcapAll("xgpon-pcap");
```

The general commands EnablePcapAll allowed the catching of all packets in XG-PON networks. That mean between OLT and ONU units. At first, the HTTP (Hyper Text Transfer Protocol) data are transferred from a WebServer to ONU1. In other words, client1 requested the website from the WebServer. Data flow can be seen in Fig. 3 and Fig. 4.

Figure 3: HTTP communication.

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	160.0.0.1	172.0.1.1	TCP	1052	49153 > http [<None>] Seq=1 Win=0, bogus TCP header length (0, m
2	0.004200	172.0.1.1	160.0.0.1	TCP	1052	http > 49153 [<None>] Seq=1 Win=0, bogus TCP header length (0, m
3	0.999625	160.0.0.1	172.0.1.1	TCP	1052	49153 > http [<None>] Seq=1 Win=0, bogus TCP header length (0, m
4	1.003825	172.0.1.1	160.0.0.1	TCP	1052	http > 49153 [<None>] Seq=1 Win=0, bogus TCP header length (0, m

Figure 4: Analysis of HTTP communication in Wireshark.

The second service simulated in designed topology was TCP stream. This stream was represented with communication between TVserver and ONU1 (see Fig. 5 and Fig. 6).

Figure 5: Communications between TVServer and ONU1 – client1

No.	Time	Source	Destination	Protocol	Length	Info
7	3.500375	160.0.0.1	172.0.0.1	TCP	1052	49154 > 50000 [<None>] Seq=1 Win=0, bogus TCP header length
8	3.504575	172.0.0.1	160.0.0.1	TCP	1052	50000 > 49154 [<None>] Seq=1 Win=0, bogus TCP header length

Figure 6: TCP communication for VoD service.

In Fig. 6 you can see TCP communication, which is used for VoD services. As was mentioned, VoD is transmitted over a TCP stream, because the stream is unique compared to IPTV, where the stream uses UDP with multicast communication. In multicast communication, only one stream is transmitted. That one stream is split by a splitter and is then distributed to all ports. At that point, it reaches all subscribers.

The last service was voice transfer. In actual networks, RTP (Real Time Transport Protocol) is used after conclusion and parameters. As we can see in Fig. 7, Wireshark does not know the version of the RTP packets. On the other hand, RTP packets show only the stream. We do not need to analyse speech of simulation and so on. We need to know the RTP protocol for transferring speech in a VoIP call between client1 and client2.

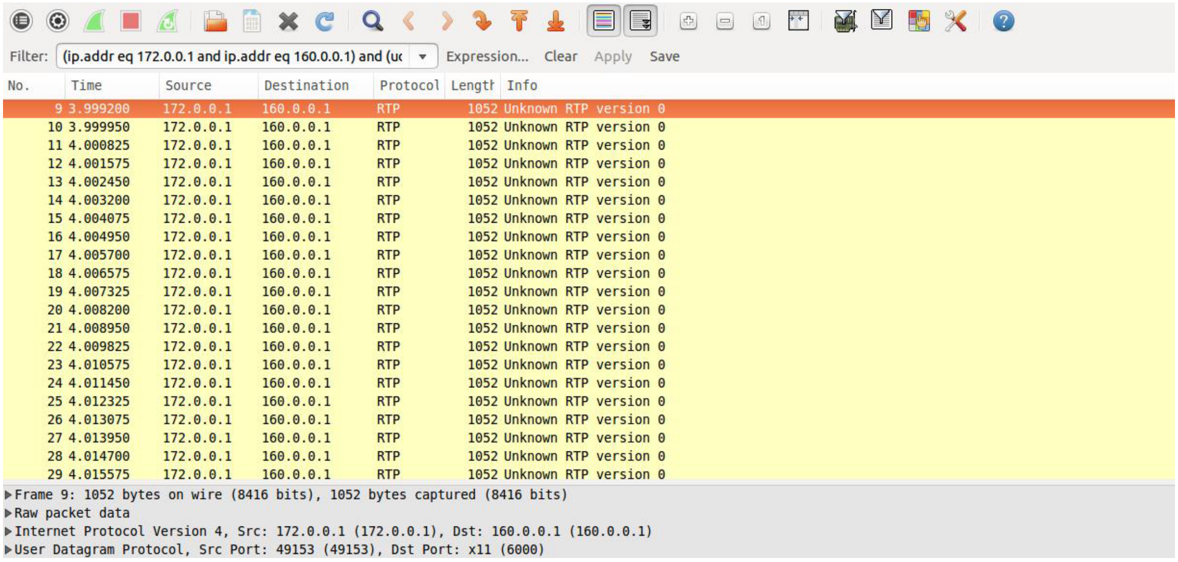

Figure 7: RTP stream for communication between client1 and client2.

5 CONCLUSION

The simulations have shown that Triple Play should be simulated in NS-3 with the XG-PON package. In general, the services are defined OnOff applications with variable parameters. NS-3 has NetAnim, which can be used to check the topology scheme and data transfer. For more details about transmitted data, it's necessary to save and view the *.pcap* file or files. These files can be opened with Wireshark for detailed analysis. The implementation of Static Bandwidth Allocation and DBA (Dynamic Bandwidth Allocation) are seen as further improvements.

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